Amendments to the Specification:

Please replace paragraph [16] with the following amended paragraph:

[16] Advantages of the invention may include one or more of the following. The system separates gingiva from tooth in a single cut. The system also reconstructs the tooth to provide a root for the tooth in the same operation. The system also generates a crown surface portion of a tooth model relatively quickly by applying the computed functions. The speed in drawing the crown surface allows real time shaping by the user when the user moves the crown control points and the top control points or when the user edits the gingival line. Also it facilitates ~~the intersection~~ **the** finding **of the intersection** ~~itself~~ as the system can rapidly determine whether a given point, such as a vertex of the tooth mesh, is inside or outside the gingival cutting surface.

Please replace paragraph [34] with the following amended paragraph:

[34] Referring now to FIG. 1A, a representative jaw 100 includes sixteen teeth, at least some of which are to be moved from an initial tooth arrangement to a final tooth arrangement. To understand how the teeth may be moved, an arbitrary centerline (CL) is drawn through one of the teeth 102. With reference to this centerline (CL), the teeth may be moved in the orthogonal directions represented by axes 104, 106, and 108 (where 104 is the centerline). The centerline may be rotated about the axis 108 (root angulation) and 104 (torque) as indicated by arrows 110 and 112, respectively. Additionally, the tooth may be rotated about the **centerline** ~~centerline, as represented by arrow 114.~~ Thus, all possible free-form motions of the tooth can be performed.

Please replace paragraph [36] with the following amended paragraph:

[36] One tool for incrementally repositioning the teeth is a set of one or more adjustment appliances. Suitable appliances include any of the known positioners, retainers, or other removable appliances that are used for finishing and maintaining teeth positions in connection with conventional orthodontic treatment. As described below, a plurality of such appliances can be worn by a patient successively to achieve gradual tooth repositioning. A particularly

advantageous appliance is the appliance <u>111</u> ~~100~~, shown in FIG. 1C, which typically comprises a polymeric shell having a cavity shaped to receive and resiliently reposition teeth from one tooth arrangement to another tooth arrangement. The polymeric shell typically fits over all teeth present in the upper or lower jaw. Often, only some of the teeth will be repositioned while others will provide a base or anchor region for holding the repositioning appliance in place as it applies the resilient repositioning force against the tooth or teeth to be repositioned. In complex cases, however, many or most of the teeth will be repositioned at some point during the treatment. In such cases, the teeth that are moved can also serve as a base or anchor region for holding the repositioning appliance. The gums and the palette also serve as an anchor region in some cases, thus allowing all or nearly all of the teeth to be repositioned simultaneously.

Please replace paragraph [37] with the following amended paragraph:

[37] The polymeric appliance <u>111</u> ~~100~~ of FIG. 1C is preferably formed from a thin sheet of a suitable elastomeric polymeric, such as Tru-Tain 0.03 in. thermal forming dental material, marketed by Tru-Tain Plastics, Rochester, Minnesota 55902. In many cases, no wires or other means are provided for holding the appliance in place over the teeth. In some cases, however, it is necessary to provide individual attachments on the teeth with corresponding receptacles or apertures in the appliance <u>111</u> ~~100~~ so that the appliance can apply forces that would not be possible or would be difficult to apply in the absence of such attachments.

Please replace paragraph [39] with the following amended paragraph:

[39] A plaster cast of the patient's teeth is obtained by well known techniques, such as those described in Graber, Orthodontics: Principle and Practice, Second Edition, Saunders, Philadelphia, 1969, pp. 401-415. After the tooth casting is obtained, the casting is digitally scanned by a scanner, such as a non-contact type laser or destructive scanner or a contact-type scanner, to produce the IDDS. The data set produced by the scanner may be presented in any of a variety of digital formats to ensure compatibility with the software used to manipulate images represented by the data. In addition to the 3D image data gathered by laser scanning or

destructive scanning the exposed surfaces of the teeth, a user may wish to gather data about hidden features, such as the roots of the patient's teeth and the patient's jaw bones. This information is used to build a detailed model of the patient's dentition and to show with more accuracy and precision how the teeth will respond to treatment. For example, information about the roots allows modeling of all tooth surfaces, instead of just the crowns, which in turn allows simulation of the relationships between the crowns and the roots as they move during treatment. Information about the patient's jaws and gums also enables a more accurate model of tooth movement during treatment. For example, an x-ray of the patient's jaw bones can assist in identifying **any close** ~~**ankylose**~~ teeth, and an MRI can provide information about the density of the patient's gum tissue. Moreover, information about the relationship between the patient's teeth and other cranial features allows accurate alignment of the teeth with respect to the rest of the head at each of the treatment steps. Data about these hidden features may be gathered from many sources, including 2D and 3D x-ray systems, CT scanners, and magnetic resonance imaging (MRI) systems. Using this data to introduce visually hidden features to the tooth model is described in more detail below.

Please replace paragraph [43] with the following amended paragraph:

[43] In step 204, final positions for the upper and lower teeth in a masticatory system of a patient are determined by generating a computer representation of the masticatory system. An occlusion of the upper and lower teeth is computed from the computer representation; and a functional occlusion is computed based on interactions in the computer representation of the masticatory system. The occlusion may be determined by generating a set of ideal models of the teeth. Each ideal model in the set of ideal models is an abstract model of idealized teeth placement, which is customized to the patient's teeth, as discussed below. After applying the ideal model to the computer representation, ~~**and**~~ the position of the teeth is optimized to fit the ideal model. The ideal model may be specified by one or more arch forms, or may be specified using various features associated with the teeth.

Please replace paragraph [57] with the following amended paragraph:

[57] Number of Erasers: A cut is comprised of multiple eraser boxes arranged next to each other as a piecewise linear approximation of the Saw Tool's curve path. The user chooses the number of erasers, which determines the sophistication of the curve created: the greater the number of segments, the more accurately the cutting will follow the curve. The number of erasers is shown graphically by the number of parallel lines connecting the two cubic B-spline curves. Once a saw cut has been completely specified the user applies the cut to the model. The cut is performed as a sequence of erasings, ~~as shown in FIG. 4A. FIG. 4B shows~~ **with** a single erasing iteration of the cut as described in the algorithm for a open ended B-spline curve. For a vertical cut, the curves are closed, with P_A [O] and P_A [S] being the same point and P_B [O] and P_B [S] being the same point.

Please replace paragraph [63] with the following amended paragraph:

[63] Next, the process 220 clips the gingiva from the tooth using a curved clipping algorithm **(260) as** described in U.S. Patent **Application Serial** No. 09/539,185, filed on March 30, 2000, entitled "System for Separating Teeth Model"; and U.S. **Patent Application Serial No.** 09/539,021, filed on March 30, 2000, entitled "Flexible Plane for Separating Teeth Model," the contents of which are incorporated by reference.

Please replace paragraph [65] with the following amended paragraph:

[65] The cutter of Fig. 5 embeds itself into the tooth to be cut. In the embodiment of Fig. 6, the cutter is shaped like an ice-cream cone, with the top surrounding the crown of a tooth 301 to be extracted, and the bottom embedded inside the gingiva 300 to define the root of the tooth 301. The gingival line or curve defines a rim 304 for this ice-cream cone shaped cutter. The cutter is shaped by several sets of control points. The points on the rim 304 (gingival curve) controls give the definition of the gingival line. This set of control points can be moved on the surface of the tooth 301. One or more crown control points 308 define the upper part of the cutter. This set of

crown control points 308 can be adjusted **to** enclose the crown part of the tooth by the upper part of the cutter. The crown control points 308 are also adjusted also so that the crown part of the gingival cutter does not cut through any gingiva 300.

Please replace paragraph [69] with the following amended paragraph:

[69] Next, along a preset number of angles around the z-axis of the tooth, the maximum curvature points along z-direction are found (step 238). These curvature points are found only in the area where a given tooth type could have gingival line. This eliminates finding ~~lot of~~ **numerous** high curvature points, which are elsewhere due to noise and tooth features themselves. A filtering procedure is used to filter out the points generated by noise in the data (step 240). As the gingival line is often not quite smooth, a smoothing procedure is applied to adjust certain points and to eliminate noisy points on the curve (step 242). A smooth spline curve is fit along the final set of points that are available after filtering and smoothing procedure (step 244). This spline curve represents the gingival line for this tooth. The spline curve can optionally be edited by moving one or more control points on this curve (step 246).

Please replace paragraph [71] with the following amended paragraph:

[71] The process of Fig. 8A models the crown surface as a spline surface which passes through the gingival line and a set of points (crown control points) around the clinical crown portion of the tooth, and a point above the top of the crown (step 252). First at a predetermined angles (phi) around z axis, the gingival curve is intersected with the half plane starting at z-axis at angle phi. Another point is computed depending up on the tooth type, a bit away from the tooth surface and above the gingival line. Quadratic curves are constructed at each angle from top control point to the gingival point and passing through the crown control point. Next, through all the points thus found for crown controls, a spline is fit around **the** ~~he~~ z-axis. Thus the crown surface is defined by ~~a~~ generating a grid of points that are quadratic along **x-axis** ~~z-axis~~ and cubic around z-axis. The crown control points can be edited to change the shape of the crown

portion of the surface (step 254). For example, the point above the top of the tooth can be moved in the z-direction to change the shape of the crown surface portion.

Please replace paragraph [74] with the following amended paragraph:

[74] The meridian curves 771, 772 and 773 are determined for each of the control angles that divide 360 degrees around z-axis into a preset number of intervals. Then the points on the meridian curves at uniform z-increments are found. These points at each of the elevations are used to construct a cubic periodic hermite curve **779** around **z-axis** ~~z-axis 779~~. Then each of these elevation curves such as curve 779 are evaluated for uniformly distributed preset number of points around the z axis. Thus using the grid of points generated by the elevation curves, meridian curves are used to generate the whole grid for the cutter.

Please replace paragraph [76] with the following amended paragraph:

[76] The initial placement of the crown control points is done using an approximate tooth shape inferred from the tooth identification information (step 256 **of Fig. 8A**). For example for a molar these points should be farther away from z-axis than for an incisor. The root part of the gingival cutting surface is then generated (step 258). The root part can be made up of a parabolic surface at the bottom of the surface and a ruled surface that connects this parabolic surface to the crown surface.

Please replace paragraph [81] with the following amended paragraph:

[81] The user interface allows the user **to** turn a solids option on and off so that the surface of the gingival cutter 500 can be visualized from its wire-frame model. The root can be displayed or can remain hidden using a transparency setting and is useful for visualizing the root structure inside the tooth. Intersection geometry can be shown, and the root and crown points and root depth can be specified.

Please replace paragraph [85] with the following amended paragraph:

[85] FIG. 14 is a simplified block diagram of a data processing system 800 that may be used to develop orthodontic treatment plans. The data processing system 800 typically includes at least one processor 802 that communicates with a number of peripheral devices via bus subsystem 804. These peripheral devices typically include a storage subsystem 806 (memory subsystem 808 and file storage subsystem 814), a set of user interface input and output devices **818** ~~318~~, and an interface to outside networks **816** ~~316~~, including the public switched telephone network. This interface is shown schematically as "Modems and Network Interface" block 816, and is coupled to corresponding interface devices in other data processing systems via communication network interface 824. Data processing system 800 could be a terminal or a low-end personal computer or a high-end personal computer, workstation or mainframe.

Please replace paragraph [90] with the following amended paragraph:

[90] File storage subsystem **814** ~~314~~ provides persistent (non-volatile) storage for program and data files, and typically includes at least one hard disk drive and at least one floppy disk drive (with associated removable media). There may also be other devices such as a CD-ROM drive and optical drives (all with their associated removable media). Additionally, the system may include drives of the type with removable media cartridges. The removable media cartridges may, for example be hard disk cartridges, such as those marketed by Syquest and others, and flexible disk cartridges, such as those marketed by Iomega. One or more of the drives may be located at a remote location, such as in a server on a local area network or at a site on the Internet's World Wide Web.